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Quality Traits of Grain- and Grass-Fed Beef: A Review

Perry Brewer
Chris Calkins[1]

Grass-fed beef is less tender and lower in flavor and acceptability than grain-fed beef.

Summary

Carcasses from grass-fed beef have lower fat thickness and lighter carcass weights, which increases the risk for cold shortening and reduces muscle proteolysis, both of which would reduce beef tenderness. A review of nine research papers indicates grass-fed beef is lower in tenderness (both from shear force and by taste panel), flavor and overall acceptability/desirability ratings.

Introduction

Recently, interest in production of grass-fed beef has increased. Proponents identify advantages of sustainability, low inputs, a more "natural" process than grain feeding, reduced use of antibiotics, leaner/healthier meat and better flavor. Opponents caution that increased production time, cost of production, seasonality of forage resources, absence of evidence demonstrating that forage finished beef is healthier, economic risk, and limited marketing potential do not support finishing cattle on grass. Although each of these points (and many others) merit a detailed discussion, this review focuses on the characteristics of the end product — beef for human consumption. The tenderness and flavor of beef finished under either system has been studied in the past and this brief review of the literature is intended to provide concrete information on this particular aspect of the issue.

Procedure

This review includes data from nine publications that compared grain-fed to grass-fed beef. There are a variety of treatments among papers and within each study. For clarity, only all-forage treatments were compared to grain feeding, except the 2000 paper by French et al. This particular publication compared a number of treatments containing forages with several that included concentrates so the means of all-forage treatments versus those containing concentrates are presented. Different taste panel rating scales were used in the studies so the data are presented as a percentage of the rating scale to facilitate direct comparisons among studies. Of course, this is not a complete list of the grain versus grass-fed beef literature. We have attempted to summarize papers where animal age appeared to be controlled and where grain feeding lasted 85 days or more.

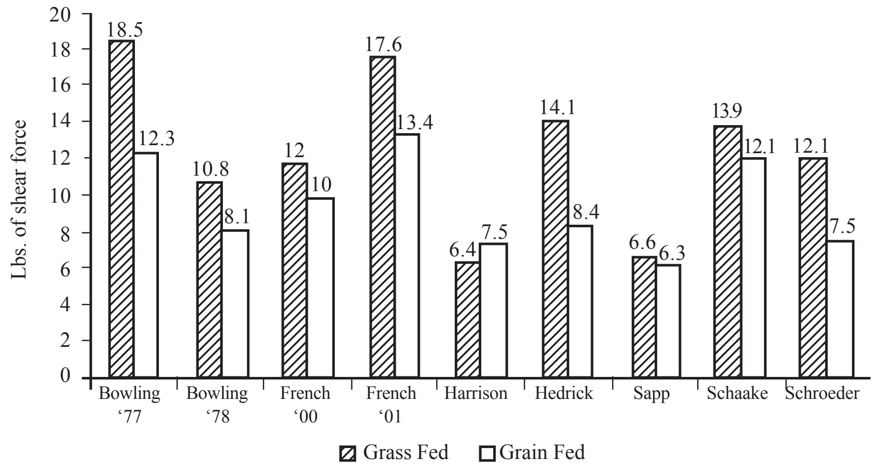

Figure 1. Warner-Bratzler shear force of grass- and grain-fed beef.

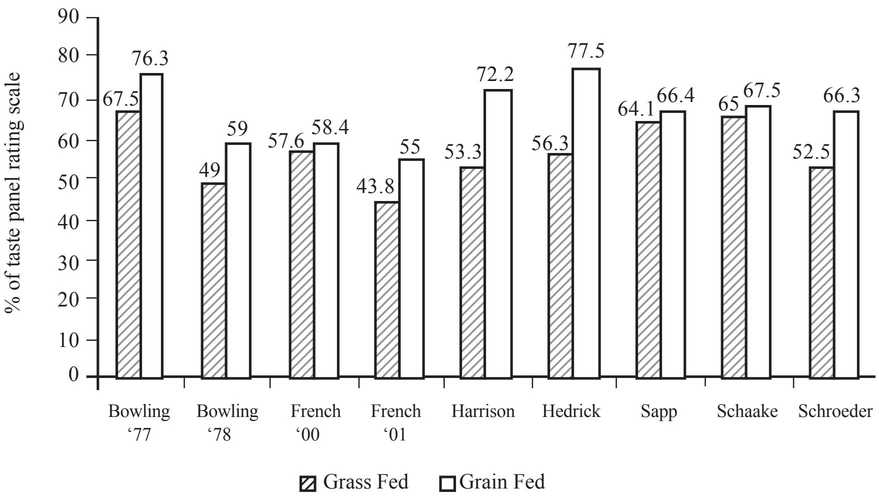

Figure 2. Taste panel tenderness ratings of grass- and grain-fed beef.

Results

Tenderness Issues

Figure 1 indicates a distinct advantage in tenderness (shear force) for grain-fed cattle versus grass-fed cattle. The only time the mean shear force for beef from grass-fed cattle was lower than for corresponding grain-fed cattle (in the Harrison et al., 1978 paper), the taste panel produced conflicting results (Figure 2). In that particular study, the taste panel ratings for tenderness were almost 2 full taste panel units lower (less tender) for the grass-fed treatment. Taken together, these data indicate that grass-fed cattle produce beef that is less tender than beef from grain-fed cattle.

Tenderness is one of the most important palatability traits influencing consumer satisfaction with beef. This complex trait can be influenced by a number of factors. These factors may be categorized as those influencing connective tissue and those influencing the muscle fiber itself.

Muscles containing more connective tissue are less tender. Connective tissue from older animals is less heat soluble than connective tissue from younger animals. So both amount and solubility of connective tissue can influence tenderness. This can best be visualized by comparing a ribeye steak to a round steak from the same animal. The later has a much greater connective tissue content and of course is less tender. A steak from a mature animal is usually less tender than one from a younger animal because the connective tissue is less heat soluble. It's possible to detect differences in tenderness among animals that have been finished as calves compared to those finished in yearling programs (see paper in this issue by Brewer et al.). Hence, anything that increases the time of production is likely to adversely affect tenderness.

A second aspect of connective tissue exists. Animals on a sub-optimal plane of nutrition frequently exhibit greater amounts of connective tissue. The hypothesis is that these animals have smaller muscle fibers. Given that each muscle fiber is covered with a layer of connective tissue, it's easy to understand that muscles with smaller fibers have proportionally more connective tissue. In effect, existing connective tissue is "diluted" by larger muscle fibers. As these fibers become smaller, the connective tissue becomes concentrated and exerts a greater influence on tenderness. This has been offered as an explanation as to why forage finished cattle have less tender meat.

Numerous factors influence the tenderness of the muscle fibers. Generally, they may be grouped into those that affect muscle fiber shortening and those that affect fragility of the muscle fibers. Implicitly, those muscles with longer fibers and those with more fragile fibers will be more tender.

A phenomenon of pre-rigor muscle is shortening in response to cold temperatures. Rapid chilling of beef carcasses, which occurs in carcasses with minimal subcutaneous fat, can increase muscle shortening. Carcasses with smaller muscle mass also chill more quickly and thus exhibit more muscle shortening. Although more gentle chilling conditions would minimize this condition, it is not recommended because of the benefits to food safety provided by rapid chilling of beef.

Fragility of the muscle fiber occurs as a result of post-mortem enzyme activity. Extended storage of beef under refrigerated conditions allows time for the natural, endogenous enzymes to function. This is the foundation of cooler aging and has been used for many years to enhance meat tenderness. More recent research clearly demonstrates that a significant increase in tenderization can occur during the hours immediately after harvest. The temperature of the meat

(Continued on next page)

Table 1. Carcass traits of grain and grass fed beef.

	Animal/ treatment	Carcass weight, lb		Fat thickness, in.		REA, in^2		KPH, %		YG		Marbling Score[a]	
		grass	grain	grass	grain	grass	grain	grass	grain	grass	grain	grass	grain
Bowling '77	30	483	476	.16	.33	9.5	11.0	2.3	3.5	2.1	2.4	8.9	9.4
Bowling '78	10	412	679	.06	.57	8.9	10.4	na	na	na	na	2.4	13.3
French '00	na												
French '01	na												
Harrison	8	573	728	.23	.26	10.3	12.1	2.7	3.3	2.7	3.3	9.5	15.4
Hedrick	27	346	646	.08	.43	7.5	10.9	1.8	2.3	1.8	3.0	5.9	13.9
Sapp	20	655	637	.32	.47	11.3	10.9	1.4	2.0	1.4	2.0	11.0	13.0
Schaake	36	621	769	.20	.51	11.6	12.9	2.4	3.2	2.2	3.2	11.0	16.3
Schroeder	7	403	690	.10	.50	8.6	11.6	2.0	2.9	1.9	3.2	5.0	12.3

[a]Small + = 15, Small 0 = 14, Small - = 13 and so on.

during chilling not only influences shortening, described in the paragraph above, but also alters the extent of muscle proteolysis. More enzyme activity occurs at warmer temperatures. Thus, muscle chilled too quickly will be less tender not only because of cold shortening, but also because the lower temperature has minimized enzyme activity. Carcasses with more subcutaneous fat chill less quickly.

None of the studies reviewed made specific measures of muscle shortening, muscle fiber fragility, or connective tissue amount. However, almost every study revealed carcasses from grass-fed cattle to be lighter in weight, with less fat, smaller ribeye areas, and lower marbling scores than carcasses from grain-fed cattle. These conditions would be expected to allow greater muscle shortening and reduce proteolysis, together with possibly smaller muscle fibers (which would generate proportionally more connective tissue).

Flavor Issues

Flavor scores from trained taste panels support the contention that flavor of beef from grain-fed cattle is more desirable than beef from grass-fed steers (Figure 3). In the seven studies that included an assessment of overall acceptability/palatability, grain-fed beef was more highly rated every time.

Although some important flavor compounds in meat reside in the lean, compounds within the fat also contribute to the flavor profile — especially in the differences among species. Implicitly, the diet of the animal will influence these flavor contributors. Recent data reported in the *2001 Beef Cattle Report*, pp. 96-98, indicate there are significant flavor differences between grain-fed and grass-fed beef and U.S. consumers strongly discriminate against the flavor of grass-fed beef. This later research was conducted with beef loins matched in tenderness, so there was no bias among the samples on the basis of texture. There were some differences in aging time between the grain-fed and grass-fed samples, but the longer aging period (which would be expected to

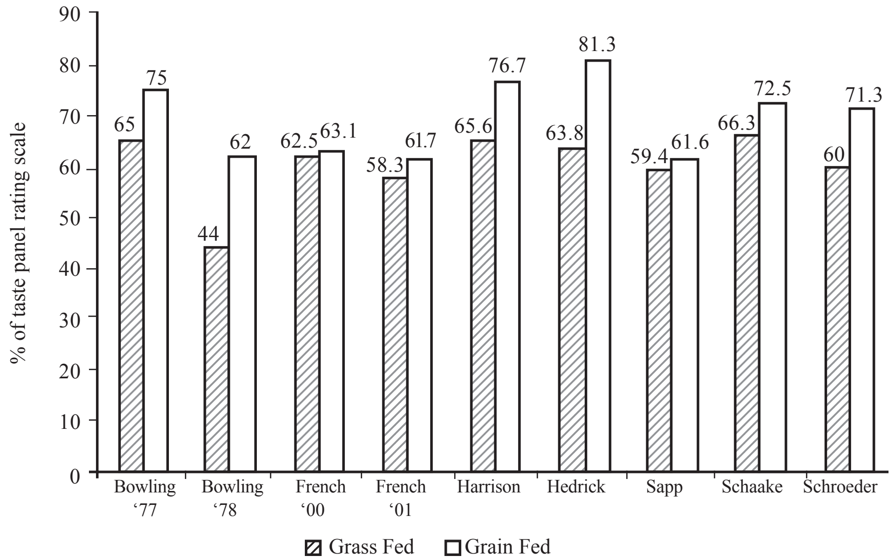

Figure 3. Taste panel flavor ratings of grass- and grain-fed beef.

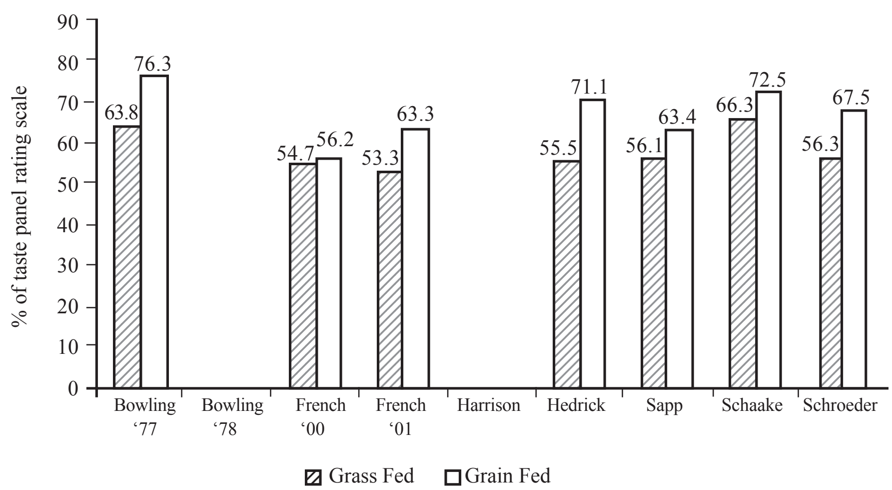

Figure 4. Taste panel overall acceptability/palatability ratings of grass- and grain-fed beef.

improve consumer acceptance of flavor) was for the grass-fed beef.

Although the preponderance of data indicate grass-fed beef is less desirable than grain-fed beef, a small niche market for grass-fed beef may exist. For those intent upon producing grass-fed beef, it would be imperative to identify a market for the meat before undertaking such a production system.

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